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USE THEREOF
Examiner: Angebrannndt, M.

Cambridge, Massachusetts
June 2, 1999

APPEAL BRIEF

Assistant Commissioner for Patents
Washington DC 20231

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AUTHORITIES RELIED UPON BY APPLICANTS

ACS Hospital Systems, Inc. v. Montefiore Hospital, 221 USPQ 929, 933 (CAFC 1984)
Lindemann Maschinenfabrik GMBH v. American Hoist and Derrick Co., 221 USPQ 481, 488 (CAFC 1984)
Panduit Corp. v. Dennison Mfg. Co., 1 USPQ2d. 1593, 1605 (CAFC 1987).
W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 311 (CAFC 1983)
Jones v. Hardy, 220 USPQ 1021, 1024 (CAFC 1984)
Glaros v. H.H. Robertson, Co., 224 USPQ 1037, 1038 (D.C.N.D. Ill. 1984)
Metronic, Inc. v. Daig Corp., 221 USPQ 595, 606 (D.C.D. Minn. 1983)
Ex parte Clapp, 227 USPQ 972 (P.O. Bd. App. Int. 1985)
In re Geiger, 2 USPQ2d 1276 (CAFC 1987)

Sir:

This is an appeal from the final rejection of claims 1-14 (all remaining claims) of the above application as set forth in the Office Action mailed November 17, 1998.

REAL PARTY IN INTEREST

The real party in interest in this appeal is Polaroid Corporation, a corporation organized and existing under the laws of the State of Delaware, of 784 Memorial Drive, Cambridge, MA 02139.

RELATED APPEALS AND INTERFERENCES

There are no related appeals and interferences.

STATUS OF CLAIMS

Claims 1-14 are pending in this application, claims 15-27 having been cancelled. Claims 1-14 stand finally rejected; no claim is objected to.

STATUS OF AMENDMENTS

Applicants were advised by an Advisory Action (Form PTO-303) mailed March 29, 1999 that their Amendment After Final Rejection filed on March 19, 1999 would be entered upon the filing of a Notice of Appeal and an Appeal Brief, so as of the filing of this Appeal Brief, all Amendments stand entered.

SUMMARY OF INVENTION

This invention relates to a process for preparing a hologram.

In prior art processes for the formation of *volume-phase* holograms, interference fringes are formed within a holographic recording medium comprising a homogeneous mixture of at least one polymerizable monomer or oligomer sensitive or sensitized to the radiation used to form the interference fringes. In the illuminated regions of the fringes, the monomer or oligomer undergoes polymerization to form a polymer that has a refractive index different from that of the binder. Diffusion of the monomer or oligomer into the illuminated regions, with consequent chemical segregation of binder from these areas and its concentration in the non-illuminated regions, produces spatial separation between the polymer formed from the monomer or oligomer and the binder, thereby providing the refractive index modulation needed to form the hologram. Typically, after the holographic exposure, a post-imaging blanket exposure of the medium to actinic radiation is required to complete the polymerization of the monomer or oligomer and fix the hologram.

A known dry-process medium for holographic recording (sold commercially by E.I. du Pont de Nemours, Inc., Wilmington DE) comprises a polymeric binder, a monomer capable of radical-initiated polymerization, and a photoinitiator (a term which is used herein to include polymerization initiators which are sensitive to radiation outside the visible range, for example ultra-violet radiation). Such a radical-polymerized medium suffers from a number of disadvantages, including severe inhibition of the radical polymerization by atmospheric oxygen, which requires precautions to exclude oxygen from the holographic medium. Also, radical polymerization often results in substantial shrinkage of the medium, with consequent

distortion of the holographic image. Furthermore, radical polymerization often results in high intensity reciprocity failure, and it is difficult to record efficiently holograms having low spatial frequency components. The commercial du Pont medium may require a lengthy thermal post-exposure treatment to further develop the index modulation of the hologram, and this thermal treatment increases the shrinkage of the hologram and distorts the fringe pattern. Finally, the du Pont medium suffers from optical inhomogeneities which impair the signal-to-noise ratio of the material, and its semisolid properties tend to result in variations in coating thickness.

One important potential use for volume holograms is in digital data storage; the three dimensional nature of a volume hologram, coupled with the high information density and parallel read/write capability which can be achieved, renders volume holograms very suitable for use in high capacity digital data storage; in theory, compact devices having storage capacities in the terabyte (10^{12} byte) range should readily be achievable. However, the aforementioned disadvantages of radical-polymerized holographic media, especially the lengthy thermal treatment, which are particularly serious when the media are to be used for digital data storage, have hitherto hindered the development of holographic data storage devices.

U.S. Patent No. 5,759,721 (which has certain inventors in common with the present application and which is assigned to the same assignee) describes holographic recording media which rely upon cationic polymerization without requiring free radical polymerization, thereby eliminating the aforementioned problems of media which use free radical polymerization. However, another important consideration in holographic recording media for digital data storage is the shrinkage of the medium during exposure. Volume phase holograms of digital data are arranged in pages, and consist of a range of grating slant angles, each angle being formed from interference of the distinct spatial frequency components of the signal beam with the reference beam. Encoding schemes such as the use of paraphase coding, data coding based upon a randomized arrangement of binary digits, and representation of data in Hamming, Reed-Solomon, and channel codes, increase the reliability of volume

holographic data storage by minimizing the effect of non-uniformities in diffraction efficiency, but although error correction codes reduce the impact of various noise contributions, they inherently involve some reduction in storage capacity. Accordingly, in designing holographic recording materials for use in digital data storage, it is important to minimize physical material contributions to noise, such as that arising from volume shrinkage of the medium during imaging.

The slant angles of volume phase holograms recorded in photopolymers are altered by anisotropic volume shrinkage, which is attributed to the increase in density occurring during the photopolymerization reactions. This shrinkage causes angular deviations in the Bragg profile which can exceed the angular bandwidth, even for moderate slant angles. For example, a volume phase plane-wave transmission hologram, with thickness of about 100 μm , and recorded with non-slant geometry, exhibits an angular profile with a Bragg peak having a full width at half height of about 0.47° . If the recording medium only undergoes shrinkage in the transverse (thickness) direction then no shift occurs in the Bragg peak angle for a non-slant hologram. For slant-fringe transmission holograms, however, shifts in the Bragg peak angle are observed due to shrinkage, regardless of shrinkage direction. The magnitude of the angle shift is dependent on the slant angle and the amount of shrinkage. The du Pont photopolymer film, HRF-150-38, exhibits a Bragg angle shift of about 2.5° for a hologram with a moderate slant angle ϕ of 18° ; see U.-S. Rhee, H. J. Caulfield, C. S. Vikram, and J. Shamir, Dynamics of hologram recording in du Pont photopolymer, *Appl. Opt.*, 34(5), 846 (1995). For a hologram of 100 μm thickness with this slant angle, the full width at half height of the Bragg peak is about 0.7° for a read beam angle 12.5° from the direction normal to the surface. For a hologram of 200 μm thickness the full width at half height is one half of the value for a hologram of 100 μm thickness. Image reconstruction (readout) of a single image, which comprises multiple gratings, is therefore likely to result in lack of image fidelity and/or distortion, unless the shrinkage is reduced to extremely low levels.

The present inventors have discovered that holographic recording media based upon a mixture of epoxide monomers of differing functionality record with reduced shrinkage, rendering these media especially suitable for use in digital data storage applications. These recording media also have lower threshold exposure energy requirements, thus allowing increased writing speed in data storage applications.

REFERENCES APPLIED BY EXAMINER

International Patent Application Publication No. WO 97/13183 (this document, hereinafter called "Dhal", is erroneously referred to as "WO/97/1318" in various Office Actions in this case, and is the International Patent Application corresponding to the aforementioned U.S. Patent No. 5,759,721)

U.S. Patent No. 5,698,345 (Ohe et al.)

U.S. Patent No. 4,950,567 (Keys et al.)

U.S. Patent No. 5,702,846 (Sato et al.)

Crivello et al., J. Polymer Sci., Vol. 28A, pp. 479-503

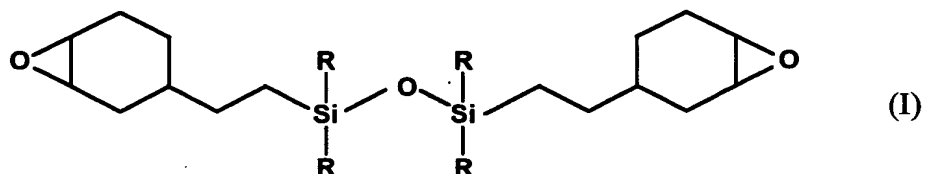
Eckburg, European Patent Application Publication No. 391,162

EXPLANATION OF THE REFERENCES

The essential disclosure of Dhal has already been set forth in the "Explanation of the Invention" section above. Dhal represents an earlier stage in the development of the present process and discloses a process in which a volume phase hologram is formed by cationic polymerization within a holographic medium. Among the cationic polymerizable monomers and oligomers disclosed in Dhal are the difunctional monomers defined in present claim 4. However, Dhal does not describe the use of the mixture of difunctional and polyfunctional monomers required by the present claims. The only discussion in Dhal regarding the choice of monomer or oligomer is the following passage (see page 6, line 21 to page 7, line 8 of Dhal):

Any monomer capable of rapid cationic polymerization may be used in the present medium and process, provided of course that, in the unexposed medium, the monomer is compatible with the other components of the holographic medium, and a wide variety of such

monomers are known to persons skilled in the polymer art. Preferred monomers for use in the present medium are those containing at least one epoxide or vinyl ether grouping, preferably a cyclohexene oxide grouping. A particularly preferred group of monomers are those in which one or more cyclohexene oxide groupings are linked to an Si-O-Si grouping; these monomers have the advantage of being compatible with polysiloxane binders. Examples of such monomers include those of the formula:



where each R independently is an alkyl group containing not more than about 6 carbon atoms. The compound in which R is a methyl group is available from General Electric Company under the tradename General Electric Silicone 479-1893. Another preferred monomer for use in the present media is 1,2-epoxy-1,2,3,4-tetrahydronaphthalene.

All the worked Examples of Dhal use either the compound of Formula (I) in which R is a methyl group or 1,2-epoxy-1,2,3,4-tetrahydronaphthalene as the polymerizable monomer.

Ohe describes a photosensitive recording material comprising a solvent-soluble, thermosetting epoxy oligomer capable of cationic polymerization, an aliphatic monomer having at least one ethylenically unsaturated bond, the monomer being liquid at normal temperature and pressure, having a boiling point of 100°C. or above at normal pressure and being capable of radical polymerization, a photoinitiator selected from the group consisting of i) a first photoinitiator capable of simultaneously generating a radical species that activates radical polymerization and a Bronsted acid or Lewis acid that activates cationic polymerization, upon exposure to actinic radiation, and ii) a second photoinitiator comprised of a radical polymerization photoinitiator capable of generating a radical species that activates radical polymerization upon exposure to actinic radiation and a cationic polymerization photoinitiator capable of generating a Bronsted acid or Lewis acid that activates cationic polymerization upon exposure to actinic radiation, and a spectral sensitizer

that sensitizes the first photoinitiator or second photoinitiator; the aliphatic monomer being mixed in an amount of from 20 parts by weight to 80 parts by weight based on 100 parts by weight of the thermosetting epoxy oligomer. Use of this photosensitive recording material is stated to be effective for producing a volume type phase hologram having superior diffraction efficiency, transparency and weatherability such as thermal resistance and being chemically stable. Columns 12-15 of this reference describe numerous cationically-polymerizable epoxide monomers and oligomers, including both difunctional and polyfunctional species. In view of the Examiner's statements in the Office Actions (quoted below), the applicants believe the Ohe is cited only to show that polyfunctional epoxide monomers and oligomers are known and are known to be capable of cationic polymerization, a proposition which the applicants have never disputed.

Keys describes a recording medium comprising a polymeric binder, an *ethylenically-unsaturated* [i.e., free-radical polymerizable] liquid monomer, a plasticizer and a photoinitiator. The photoinitiator is explicitly stated to be one which directly furnishes free radicals which activated by actinic radiation (see column 7, lines 8-10 of Keys), as indeed the photoinitiator must be to polymerize the ethylenically-unsaturated monomers used, which are capable of free radical but not cationic polymerization. Column 6, lines 17-45 of Keys states that where cross-linking is desirable, for example during thermal enhancement or curing, up to about 5 weight percent of at least one multifunctional monomer *containing two or more terminal ethylenically unsaturated groups* typically is incorporated into the photopolymerizable layer (emphasis added).

Sato describes a photosensitive composition for volume hologram recording, comprising the following components: (A) a cationic polymerizable compound and a radical polymerizable compound, (B) a cationic polymerization initiating material, and (C) a radical polymerization initiating material, as an essential component, wherein at least one of the cationic polymerizable compound and radical polymerizable compound of the component contains a siloxane group, and the

difference in refractive index between the cationic polymerizable compound and the radical polymerizable compound is not less than 0.01. The Examiner has cited the passage at column 3, line 5 to column 4, line 4 of this patent as showing that the use of compounds having a siloxane group (including compounds embraced by Formula I above) increases refractive index modulation.

Crivello is cited to show the use of various epoxy silane compounds, including those shown in Table I and II of the present application (see pages 11-13 of this application).

Eckburg is cited to show the use of cationically curable compounds embraced by the formula shown on page 5 of this reference with cationic photoinitiators.

ISSUES

The issues to be decided in this Appeal are:

- (a) Whether claims 1-4 and 12-14 are unpatentable under 35 USC 103(a) over Dhal in view of Ohe and Keys
- (b) Whether claims 1-4 and 12-14 are unpatentable under 35 USC 103(a) over Dhal in view of Ohe, Keys and Sato;
- (c) Whether claims 1-14 are unpatentable under 35 USC 103(a) over Dhal in view of Ohe, Keys and Crivello and/or Eckburg

It is believed that a full statement of these rejections is contained in the following extracts from the Office Actions issued in connection with this application.

The relevant rejections were first made in the Office Action mailed June 9, 1998, in the following terms:

24 Claims 1-4 and 12-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/13118, in view of Ohe et al. '345 and Keys et al. '567.

Dhal et al. WO/97/13118 teaches the use of compositions including at least one monomer or oligomer capable of undergoing cationic photopolymerization. The use of any monomer capable of undergoing cationic polymerization is disclosed on pages 6 and 7. Useful

photosensitizers and photoinitiators are disclosed on pages 5 and 7. Useful binders are disclosed on page 4.

Ohe et al. '345 teaches the use of cationically polymerizable materials which result in improved diffraction efficiency and superior environmental properties. Useful epoxides include those disclosed in columns 12-15.

Keys et al. '567 teaches that when more crosslinking is desired, the use of multi functional monomers in amounts up to 5% is a means to achieves this.

It would have been obvious to one skilled in the art to add other, multi functional epoxy monomers/oligomers, such as those disclosed by Ohe et al. '345, to the composition of Dhal et al. WO/97/13118 and use them in forming a hologram based upon the direction to use more than one and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/13118 reference, their previous use within the holographic art by Ohe et al. '345 and the direction to the addition of polyfunctional monomers when increased crosslinking is desired in the holographic art by Keys et al. '567.

25 Claims 1-4 and 12-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/13118, in view of Ohe et al. '345, Keys et al. '567 and Sato et al. '846.

Sato et al. '846 teaches useful cationic polymerizable compounds (3/5-4/4) The use of compounds having a siloxane group increases, refractive index modulation. This includes compounds embraced by formula (I).

In addition to the basis provided above, the examiner holds that it would have been obvious to use other siloxane compounds known to be useful cationically polymerizable materials, such as those disclosed by Sato et al. '846, in place of those specifically used in the examples of Dhal et al. WO/97/13118 as modified by Ohe et al. '345 and Keys et al. '567 with a reasonable expectation of achieving comparable results and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/13118 reference.

26 Claims 1-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/13118, in view of Ohe et al. '345, Keys et al. '567 and Crivello et al. J. Polymer Sci. and/or Eckberg et al. BP 0391162.

Crivello et al. J. Polymer Sci., Vol. 28A pp. 479-503 teaches the use of various epoxy silane compounds including those shown in tables I and II. Useful properties appear in pp. 501-503.

Eckberg et al. EP 0391162 teaches the use of cationically curable compounds embraced by the formula shown in the abstract and on page 5 with cationic photoinitiators.

In addition to the basis provided above, the examiner holds that it would have been obvious to use other siloxane compounds known to be useful cationically polymerizable materials, such as those disclosed by Crivello et al. J. Polymer Sci. and/or Eckberg et al. EP 0391162, in place of those specifically used in the examples of Dhal et al. WO/97/13118 as modified by Ohe et al. '345 and Keys et al. '567 with a reasonable expectation of achieving comparable results and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/13118 reference.

Following the presentation of arguments essentially as set forth below, these rejections were repeated in the final Office Action mailed November 17, 1998 in the following terms:

3 Claims 1-4 and 12-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/1318, in view of Ohe et al. '345 and Keys et al. '567.

Dhal et al. WO/97/1318 teaches the use of compositions including at least one monomer or oligomer capable of undergoing cationic photopolymerization. The use of any monomer capable of undergoing cationic polymerization is disclosed on pages 6 and 7. Useful photosensitizers and photoinitiators are disclosed on pages 5 and 7. Useful binders are disclosed on page 4.

Ohe et al. '345 teaches the use of cationically polymerizable materials which result in improved diffraction efficiency and superior environmental properties. Useful epoxides include those disclosed in columns 12-15.

Keys et al. '567 teaches that when more crosslinking is desired, the use of multi functional monomers in amounts up to 5% is a means to achieves this.

It would have been obvious to one skilled in the art to add other, multi functional epoxy monomers/oligomers, such as those disclosed by Ohe et al. '345, to the composition of Dhal et al. WO/97/1318 and use them in forming a hologram based upon the direction to use more than one and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/1318 reference, their previous use within the holographic art by Ohe et al. '345 and the

direction to the addition of polyfunctional monomers when increased crosslinking is desired in the holographic art by Keys et al. '567.

The applicant argues that the combination of the references does not show the benefit discovered by the applicants, in that minimal shrinkage occurs when difunctional and polyfunctional monomers are used. The applicant agrees that using tri or higher functional monomers will rigidify the resulting polymeric structure and that this is well known in polymer technology. The applicant argues that this teaching has nothing to do with the benefits achieved by or problems solved by the applicants. The examiner disagrees, noting that increased crosslinking and the resultant increase in rigidity due to it would be expected to reduce shrinkage as *the more rigid structure would be more resistant to forces acting upon it*. This would be appreciated for polyfunctional monomers irrespective of the mechanism by which the crosslinking occurs. The increased rigidity and reduced shrinkage due to that rigidity would be expected with increased crosslinking for both cationic and free radical polymerization systems. Direction to use increased crosslinking within the art is shown by Keys et al. '567 and as similar enhancement processes are used, would be expected to achieve similar benefits. Additionally, increased refractive index modulation and resistance to abrasion and/or swelling (causing drift of replay wavelength) could reasonably be expected by one skilled in the art. The rejection is maintained.

4 Claims 1-4 and 12-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/1318, in view of Ohe et al. '345, Keys et al. '567 and Sato et al. '846.

Sato et al. '846 teaches useful cationic polymerizable compounds (3/5-4/4). The use of compounds having a siloxane group increases, refractive index modulation. This includes compounds embraced by formula (I).

In addition to the basis provided above, the examiner holds that it would have been obvious to use other siloxane compounds known to be useful cationically polymerizable materials, such as those disclosed by Sato et al. '846, in place of those specifically used in the examples of Dhal et al. WO/97/1318 as modified by Ohe et al. '345 and Keys et al. '567 with a reasonable expectation of achieving comparable results and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/1318 reference.

No further response is presented as no further arguments are forwarded by the applicant.

5 Claims 1-14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhal et al. WO/97/1318, in view of Ohe et al. '345, Keys et al. '567 and Crivello et al. J. Polymer Sci. and/or Eckberg et al. EP 0391162.

Crivello et al. J. Polymer Sci., Vol. 28A pp. 479-503 teaches the use of various epoxy silane compounds including those shown in tables I and II. Useful properties appear in pp. 501-503.

Eckberg et al. EP 0391162 teaches the use of cationically curable compounds embraced by the formula shown in the abstract and on page 5 with cationic photoinitiators.

In addition to the basis provided above, the examiner holds that it would have been obvious to use other siloxane compounds known to be useful cationically polymerizable materials, such as those disclosed by Crivello et al. J. Polymer Sci. and/or Eckberg et al. EP 0391162, in place of those specifically used in the examples of Dhal et al. WO/97/1318 as modified by Ohe et al. '345 and Keys et al. '567 with a reasonable expectation of achieving comparable results and that any cationically polymerizable compound(s) would be useful in the composition within the Dhal et al. WO/97/1318 reference.

No further response is presented as no further arguments are forwarded by the applicant.

GROUPING OF CLAIMS

Pursuant to 37 CFR 1.192(c)(5), applicants are content to have all of the claims on appeal assessed as a single group.

ARGUMENT

Summary

Issue (a) There is no incentive to combine Dhal, Ohe and Keys in the manner suggested by the Examiner. The purported incentives proposed by the Examiner for this combination are *ex post facto* rationalizations for the combination; these rationalizations may indeed be related to certain physical parameters which might ultimately explain why the present invention works, but they are not incentives which would lead a skilled person to solve the problem encountered in the prior art, and it is this type of incentive which is required by the governing law.

Issues (b) and (c) The remaining rejections fail for the same reasons as set forth under Issue (a) above.

Relevant case law

The law governing this matter is that of the Court of Appeals for the Federal Circuit, which has repeatedly stated that references may only be combined where one of ordinary skill in the art would have some suggestion or incentive to effect the suggested combination. For example, in *ACS Hospital Systems, Inc. v. Montefiore Hospital*, 221 USPQ 929, 933 (CAFC 1984), the Court stated that:

Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention absent some teaching or suggestion supporting the combination [citations omitted]. Under section 103, teachings of references can be combined only if there is some suggestion or incentive to do so. [Emphasis in original.]

Furthermore, in *Lindemann Maschinenfabrik GMBH v. American Hoist and Derrick Co.*, 221 USPQ 481, 488 (CAFC 1984), the Court of Appeals for the Federal Circuit upheld a patent notwithstanding that it:

specifically stated that it disclosed and claimed a combination of features previously used in two separate devices. That fact alone is not fatal to patentability. The claimed invention must be considered as a whole, and the question is whether there is something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination.

It is reversible error to find obviousness merely on the basis that all the elements of a claimed combination are present in separate prior patents where the elements differ greatly in shape, position, relation, combination, and function. See *Panduit Corp. v. Dennison Mfg. Co.*, 1 USPQ2d. 1593, 1605 (CAFC 1987).

Similarly, in *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 220 USPQ 303, 311 (CAFC 1983), the Court stated:

In concluding that obviousness was established by the teachings in various pairs of references, the District Court lost sight of the principle that there must have been something present in the teachings to suggest to one skilled in the art that the claimed invention before the Court would have been obvious.

The foregoing cases have frequently been cited as representing the considered judgment of the Court of Appeals for the Federal Circuit regarding the combination of references; see, inter alia, *Jones v. Hardy*, 220 USPQ 1021, 1024 (CAFC 1984) and *Glaros v. H.H. Robertson, Co.*, 224 USPQ 1037, 1038 (D.C.N.D. Ill. 1984). See also

Metronic, Inc. v. Daig Corp., 221 USPQ 595, 606 (D.C.D. Minn. 1983) and *Ex parte Clapp*, 227 USPQ 972 (P.O. Bd. App. Int. 1985).

Furthermore, even though one skilled in the art might find it obvious to try various combinations of known agents, in view of the references sought to be combined, such combinations do not necessarily provide a prima facie case of obviousness under 35 USC 103. See *In re Geiger*, 2 USPQ2d 1276 (CAFC 1987).

Detailed argument

Issue (a)

(a) There is no incentive to combine Dhal, Ohe and Keys

As discussed in the "Summary of the Invention" section above, the essential problem facing the present inventors was to provide a holographic recording process which maintained the advantages of the Dhal composition (namely the low reciprocity failure, elimination of a post-exposure heating step, and freedom from optical inhomogeneities) but which allowed reduced shrinkage during the exposure step, and thus gave promise of greater suitability for high density digital data recording.

As already noted, applicants concede that Dhal describes a process which is generally similar to that of the present invention except that it does not use a mixture of difunctional and polyfunctional epoxide monomers, and that Dhal describes compositions using the difunctional monomer of present claim 4. Applicants further concede that polyfunctional epoxide monomers are known, and are known to be capable of cationic polymerization; see, for example, U.S. Patent No. 5,037,861 (noted at page 7, line 7 of this application), column 1, lines 26-38 and column 3, lines 24-27, which describe polyfunctional epoxide monomers of Formula (II) on page 7 of this application, and their cationic polymerization. Ohe shows only that polyfunctional epoxide monomers are known, and are known to be capable of cationic polymerization. However, there is nothing in Dhal or Ohe to indicate that adding a polyfunctional epoxide monomer to the difunctional epoxide monomers used in Dhal

will provide a medium with the minimal shrinkage required for good digital data storage holographic performance.

Keys does nothing to remedy this crucial lack of linkage between Dhal and Ohe. The Examiner has alleged that "Keys . . . teaches that when more cross-linking is desired, the use of multi functional monomers in amounts up to 5% is a means to achieve this." The undersigned attorney assumes that this paragraph is intended to refer to column 6, lines 17-45 of Keys. However, Keys describes a recording medium comprising a polymeric binder, an *ethylenically-unsaturated* [i.e., free-radical polymerizable] liquid monomer, a plasticizer and a photoinitiator. The photoinitiator is explicitly stated to be one which directly furnishes free radicals which activated by actinic radiation (see column 7, lines 8-10 of Keys), as indeed the photoinitiator must be to polymerize the ethylenically-unsaturated monomers used, which are capable of free radical but not cationic polymerization. The aforementioned passage at column 6, lines 17-45 of Keys states that where cross-linking is desirable, for example during thermal enhancement or curing, up to about 5 weight percent of at least one multifunctional monomer *containing two or more terminal ethylenically unsaturated groups* typically is incorporated into the photopolymerizable layer (emphasis added). This is not surprising, since the use of tri- or higher functional unsaturated monomers to rigidify polymers is well known in polymer technology, as the Board is no doubt aware. However, this statement would not do anything to direct the skilled person toward a solution to the problem facing the present inventors, namely providing a holographic process with the advantages of the Dhal process but with reduced shrinkage

Firstly, Keys recommends the use of di- or polyfunctional ethylenically-unsaturated monomers to rigidify a polymer formed by free radical polymerization of ethylenically-unsaturated monomers. There is nothing in the present record to show that this rigidifying effect can be extrapolated from polymers formed from ethylenically-unsaturated monomers to polymers formed by cationic polymerization of epoxide monomers.

Secondly and more importantly, persons skilled in the art of holography would not be concerned about rigidifying the exposed Dhal composition. The Dhal composition is intended for use in digital data storage holograms, and in this application the physical properties of the recording medium are of relatively little importance, provided only that the hologram itself is stable; the recording medium is typically carried on a carrier (for example, the glass slides used in the experimental apparatus of the Example in Dhal) which provides mechanical support to the hologram.

Finally, Keys is completely irrelevant to the actual problem facing the inventors, which was to produce a holographic recording medium with reduced shrinkage. There is nothing in the references of record to suggest any correlation between rigidifying and reducing shrinkage, and the applicants are not aware of any such correlation. Moreover, even if it could be shown that the rigidification effected by use of multifunctional monomers in Keys was associated with reduction of shrinkage, one could not extrapolate from the Keys to the Dhal compositions, since the two polymerizations are of completely different types. The free radical polymerization used in Keys essentially converts a plurality of vinyl groups containing sp^2 carbon atoms to a saturated polymethylene chain, whereas the Dhal cationic polymerization converts saturated epoxide rings to polymethylene chains. It will readily be apparent that the change in molecular volumes, and hence the shrinkage of the medium involved, will be very different in the two cases.

(b) The purported incentives proposed by the Examiner for the Dhal/Ohe/Keys combination are *ex post facto* rationalizations

As quoted at length above, in the final Office Action, the Examiner took issue with the foregoing argument, noting that increased crosslinking and the resultant increase in rigidity due to it would be expected to reduce shrinkage as *the more rigid structure would be more resistant to forces acting upon it* (emphasis in original), and this would be appreciated for polyfunctional monomers irrespective of the mechanism by which the crosslinking occurs. Additionally, the Examiner stated, increased

refractive index modulation and resistance to abrasion and/or swelling (causing drift of replay wavelength) could reasonably be expected by one skilled in the art.

This argument confuses the mechanical behavior of a formed polymer in response to forces acting thereon, with the behavior of a mixture of monomers undergoing polymerization to form a polymer. Obviously, the more rigid a finished polymer, the greatest its resistance to forces acting on it, and the less the deformation caused by such forces. However, the reduced shrinkage with which this invention is concerned is not a property of the final polymer, but rather of the difference between the volumes of the unpolymerized mixture of monomers and the partially polymerized illuminated regions of the hologram. There is no *a priori* logical correlation between the volume change during the polymerization step and the rigidity of the final product, and nothing in any of the references indicates any empirical correlation on this point. Indeed, to the extent that most polymerizations are accompanied by some shrinkage (as might be expected in view of the fact that the new bonds formed during polymerization reduce the distances between adjacent atomic nuclei from the larger Van der Waals distance to the smaller distance characteristic of a covalent bond), the increased number of covalent bonds formed by incorporation of multifunctional monomers might be expected to increase shrinkage rather than decrease it. At the least, it would not be possible for the skilled worker to predict in advance what effect incorporation of the polyfunctional monomer would have on the shrinkage of the holographic medium.

Furthermore, the Examiner is not justified in concluding, on the basis of Keys, that the use of polyfunctional monomers would lead to increased refractive index modulation. If the Examiner is saying that use of multifunctional monomers would be expected to lead to a denser polymer, and hence to greater refractive index changes (increased refractive index usually being associated with increased average electron density within a solid), this may well be true, but increased polymer density necessarily implies greater shrinkage during polymerization, which is the opposite of the effect achieved by the present invention.

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Issues (b) and (c)

Since the two rejections designated herein as Issues (b) and (c) both rely upon the Dhal/Ohe/Keys combination discussed above, these rejections fail for the same reasons as set forth under Issue (a) above.

CONCLUSION

For all of the foregoing reasons, the 35 USC 103 rejections of the claims on appeal should be reversed and the application allowed.

Respectfully submitted,



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APPENDIX

Claims on Appeal

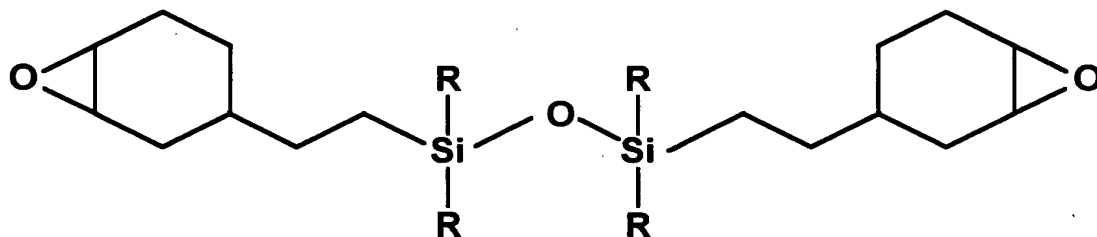
1 1. A process for preparing a hologram, which process comprises:
2 providing a holographic recording medium comprising an acid
3 generator capable of producing an acid upon exposure to actinic radiation; a binder; a
4 difunctional epoxide monomer or oligomer; and a polyfunctional epoxide monomer or
5 oligomer, the difunctional and polyfunctional epoxide monomers or oligomers being
6 capable of undergoing cationic polymerization initiated by the acid produced from the
7 acid generator; and

8 passing into said medium a reference beam of coherent actinic radiation
9 to which the acid generator is sensitive and an object beam of the same coherent
10 actinic radiation, thereby causing the reference beam and object beam to interfere
11 within said medium and causing cationic polymerization therein, thereby forming a
12 hologram within said medium.

1 2. A process according to claim 1 wherein at least one of the
2 difunctional epoxide monomer or oligomer and the polyfunctional epoxide monomer
3 or oligomer comprises a siloxane.

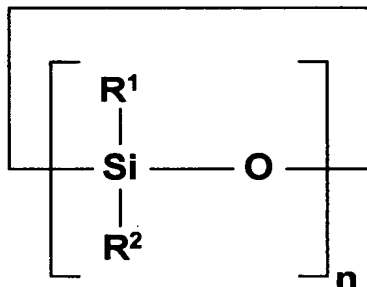
1 3. A process according to claim 1 wherein at least one of the
2 difunctional epoxide monomer or oligomer and the polyfunctional epoxide monomer
3 or oligomer comprises an cycloalkene oxide.

1 4. A process according to claim 3 wherein the difunctional epoxide
2 monomer is of the formula:



wherein each R independently is an alkyl or cycloalkyl group.

5. A process according to claim 2 wherein the polyfunctional epoxide monomer is of the formula:



wherein each group R^1 is, independently, a monovalent substituted or unsubstituted C_{1-12} alkyl, C_{1-12} cycloalkyl, aralkyl or aryl group; each group R^2 is, independently, R^1 or a monovalent epoxy functional group having 2–10 carbon atoms, with the proviso that at least three of the groups R^2 are epoxy functional; and n is from 3–10.

6. A process according to claim 5 wherein the polyfunctional epoxide monomer is 1,3,5,7-tetrakis(2-(3,4-epoxycyclohexyl)ethyl)-1,3,5,7-tetramethylcyclotetrasiloxane.

7. A process according to claim 2 wherein the polyfunctional epoxide monomer is of the formula:



R^3 is an $\text{OSi}(\text{R}^4)_2\text{R}^5$ grouping, or a monovalent substituted or unsubstituted C_{1-12} alkyl, C_{1-12} cycloalkyl, or aryl group; each group R^4 is, independently, a monovalent substituted or unsubstituted C_{1-12} alkyl, C_{1-12} cycloalkyl, aralkyl or aryl group; and each group R^5 is, independently, a monovalent epoxy functional group having 2–10 carbon atoms.

8. A process according to claim 7 wherein R^3 is a methyl group or an $\text{OSi}(\text{R}^4)_2\text{R}^5$ grouping; each group R^4 is a methyl group, and each group R^5 is a 2-(3,4-epoxycyclohexyl)ethyl grouping.

9. A process according to claim 2 wherein the polyfunctional epoxide monomer is of the formula:



each group R⁶ is, independently, a monovalent substituted or unsubstituted C₁₋₁₂ alkyl, C₁₋₁₂ cycloalkyl, aralkyl or aryl group; each group R⁷ is, independently, a monovalent substituted or unsubstituted C₁₋₁₂ alkyl, C₁₋₁₂ cycloalkyl, aralkyl or aryl group; each group R⁸ is, independently, a monovalent epoxy functional group having 2-10 carbon atoms, and *p* and *q* are integers.

10. A process according to claim 9 wherein each group R⁶ and R⁷ is an alkyl group.

11. A process according to claim 10 wherein each group R⁸ is an 2-(3,4-epoxycyclohexyl)ethyl grouping and *p* and *q* are approximately equal.

12. A process according to claim 1 wherein the holographic medium comprises from about 0.2 to about 5 parts by weight of the difunctional epoxide monomer or oligomer per part by weight of the polyfunctional epoxide monomer or oligomer.

13. A process according to claim 1 wherein the holographic medium comprises from about 0.16 to about 5 parts by weight of the binder per total part by weight of the difunctional epoxide monomer or oligomer and the polyfunctional epoxide monomer or oligomer.

14. A process according to claim 1 wherein the volume shrinkage of the holographic medium during the formation of the hologram does not exceed about 1 per cent.

CERTIFICATE OF MAILING

I hereby certify that this paper, dated June 2, 1999, is being deposited with the United States Postal Service as first class mail in an envelope addressed to Assistant Commissioner for Patents, Washington DC 20231, on *June 2, 1999*.


David J. Cole